STAFF SUMMARY SHEET

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1	DFR	sig	*Phil Zroy* MABRY AD-25 20JAN12	6			
2	DFER	approve	*Brent A Richov, Col* 27 Jan 2012	7			
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SUBJECT	DATE
Clearance for Material for Public Release USAFA-DF-PA-25	20120120

SUMMARY

1. PURPOSE. To provide security and policy review on the document at Tab 1 prior to release to the public.

2. BACKGROUND.
Authors: Lionel Magee, Aaron Oats, and Michael Courtney

Title: Comparing Measured Bullet Weight with Manufacturer Specifications

Circle one: Abstract   (Tech Report)   Journal Article   Speech   Paper   Presentation   Poster

Thesis/Dissertation   Book   Other: _____

Check all that apply (For Communications Purposes):

[X] CRADA (Cooperative Research and Development Agreement) exists

[] Photo/ Video Opportunities   [] STEM-outreach Related   [] New Invention/ Discovery/ Patent

Description: Scientific paper.

Release Information: DoD Technical Report (DTIC) and submission to Accurate Shooter online magazine

Previous Clearance information: (If applicable) Not Applicable.

Recommended Distribution Statement: Distribution A: approved for public release, distribution unlimited

3. DISCUSSION. Not applicable.

4. RECOMMENDATION. Sign coord block above indicating document is suitable for public release. Suitability is based solely on the document being unclassified, not jeopardizing DoD interests, and accurately portraying official policy.

(signature)
(signature)
Michael Courtney, PhD AD-25
Director, Quantitative Reasoning Center
Assistant Professor of Mathematical Sciences

1 Tab
1. Comparing Measured Bullet Weight with Manufacturer Specifications

Comparing Measured Bullet Weight with Manufacturer Specifications

Lionel Magee, Aaron Oats, and Michael Courtney
U.S. Air Force Academy, 2354 Fairchild Drive, USAF Academy, CO 80840
Michael.Courtney@usafa.edu

Abstract

Most rifle bullets are sold with a nominal bullet weight listed on the box, but few boxes give the tolerance or uncertainty of the bullet weight. This article presents careful measurements of bullet weight, giving the mean, standard deviation, and extreme spread for a number of makes and models. Since Berger Bullets is the only company (to the authors' knowledge) to publish bullet weight tolerances, the weight measurements of several makes of Berger Bullets are graphed in comparison with their weight specifications. Bullets were measured from 49 boxes representing seven different manufacturers and calibers from 0.224 inches to 0.308 inches. The smallest standard deviation was 0.038% (Berger 168 grain VLD in 0.308) and the largest standard deviation was 0.470% (the lead-free 50 grain Barnes Varmint Grenade in 0.224). Bullets showed a distinct trend for lead-free bullets to have greater weight variations than conventional jacketed lead construction and for military bullets to have greater weight variations than commercial bullets designed for hunting and target applications.

Introduction

Whether you are a competition shooter or an avid hunter, bullet choice is important. With numerous bullet manufacturers out there such as Berger, Nosler, Hornady, Sierra, and Speer, a question considered by shooters is: which company produces the most consistent bullet? This paper contains the results of popular brands of bullets weighed individually, and compared against manufacturer claims, revealing which bullets are actually within the manufacturer tolerances. Because Berger is the only company for which we could find published tolerances, Berger tolerances were chosen as a basis for comparison. Of course, there are other possible measures of bullet consistency: bearing surface, length, etc. In some ways, bullet weight is appealing, because it easy to measure and a reasonable proxy for overall consistency of bullet manufacture. Also, if a bullet has a weight above or below the average, the extra or missing weight will affect the location of the center of mass and possibly how close the geometric center is from the center of mass. In the barrel, the rifling constrains the bullet to spin around its geometric center. In flight, the bullet spins about its center of mass. The larger the physical separation between these two points, the less likely each bullet is to fly the same once it leaves the barrel. In addition, bullets varying in weight will also likely produce shot to shot variations in muzzle velocity and ballistic coefficient which will likely produce variations in long range trajectories. Weight tolerances can also be important because some states and competitions require bullets to meet either minimum or maximum weight requirements.

Figure 1: Analytical scale with 62 grain Berger Flat Base Varmint bullet.

Method

A Sartorius GD503 Analytical Balance was used to weigh each bullet individually in grams to a resolution of 0.1 milligrams. Bullet weights were then entered into a spreadsheet and converted to grains. From there the extreme weights, average weight, and the standard deviation were calculated. Data was sorted by weight and then plotted which provides visual indication of the weight distribution of the bullets. Berger's tolerances are also graphed. Prior to acquisition of the GD503 Analytical Balance, a number of bullets were weighted on an Acculab VIC-123 with 1 mg resolution. Since this resolution is much smaller than the variation of most bullets, this data is included because it significantly broadens the body of data available for comparison. (See Appendix.)
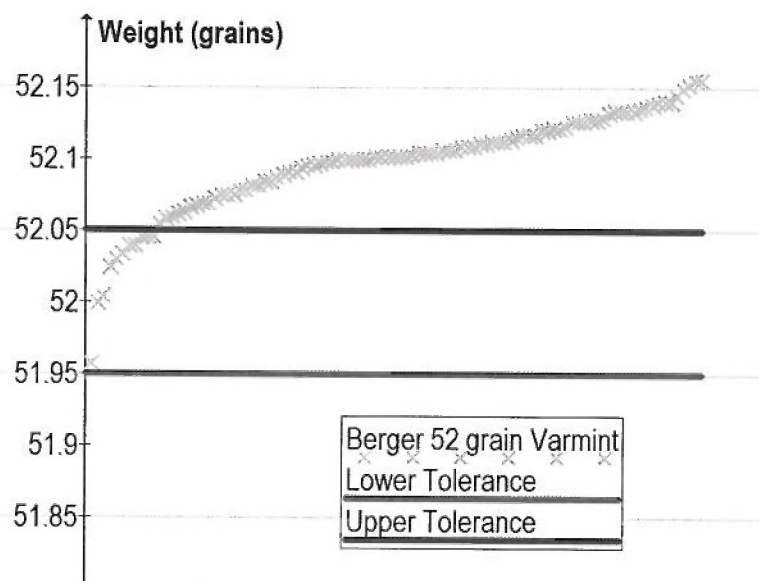

Figure 2: Weight of 52 grain Berger Varmint (0.224).

Results

Berger 52 grain Varmint (0.224)

Berger claims that for its 52 grain bullets that the weight tolerances allow for a deviation of +/- 0.05 grains and that the actual tolerances are usually tighter. To test this, 100 52 grain bullets were measured in grams, and then converted to grains using the conversion factor of 1 gram = 15.432 358 353 grains. Results are shown in Figure 2. The mean bullet weight is close to 52.1 grains at 52.097 grains with a standard deviation of 0.0354 grains. The extreme spread is 0.1975 grains. Clearly, most of the bullets in this box were outside of the manufacturer's specification.

Berger 62 grain Varmint (0.224)

Berger claims that its weight tolerances allow for a deviation of +/- 0.1 grain for their 62 grain bullets, which is twice as broad a range as their 20 to 60 grain bullets. The box of bullets shown in Figure 3 had all 100 bullets within this tolerance, with a mean of 62.031 grains, a standard deviation of 0.032 grains, and an extreme spread of 0.160 grains. It is also notable that one of the authors (MC) has found this bullet to be very satisfyingly accurate in his Rem 700 ADL chambered in .223 Remington.
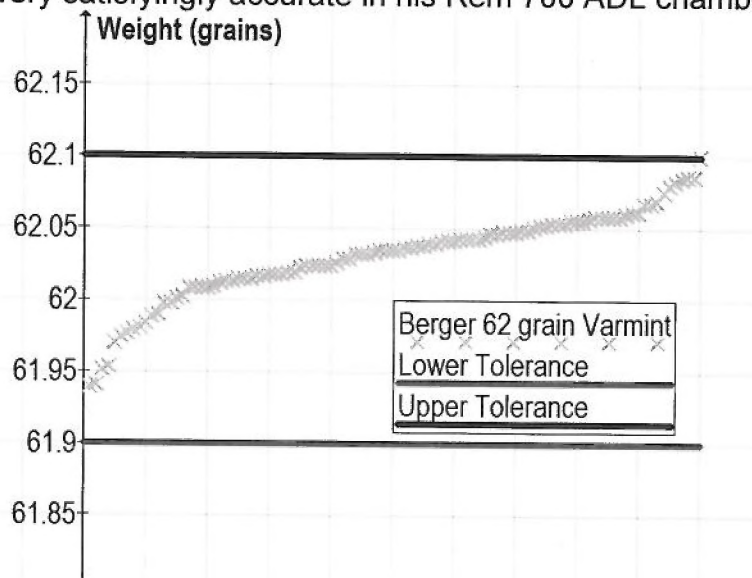

Figure 3: Bullet weights for 62 grain Berger Flat Base Varmint.

Berger 115 grain VLD (0.257)

The weight tolerance claimed by Berger for the 115 grain VLD is +/- 0.1 grains. The measured bullet weights are shown in Figure 4. Roughly 20% of the bullets weighed are out of the specification, too heavy. The mean bullet weight was 115.053 grains with a standard deviation of 0.051 grains. The mean and standard deviation leave a significant percentage of the bullets above the maximum weight. In spite of this variation, this bullet has one of the smallest variations measured, the smallest variation among the .257 inch bullets considered here, and is the most accurate bullet ever tested in the 25-06 Remington 700 Sendero of one of the authors (MC).
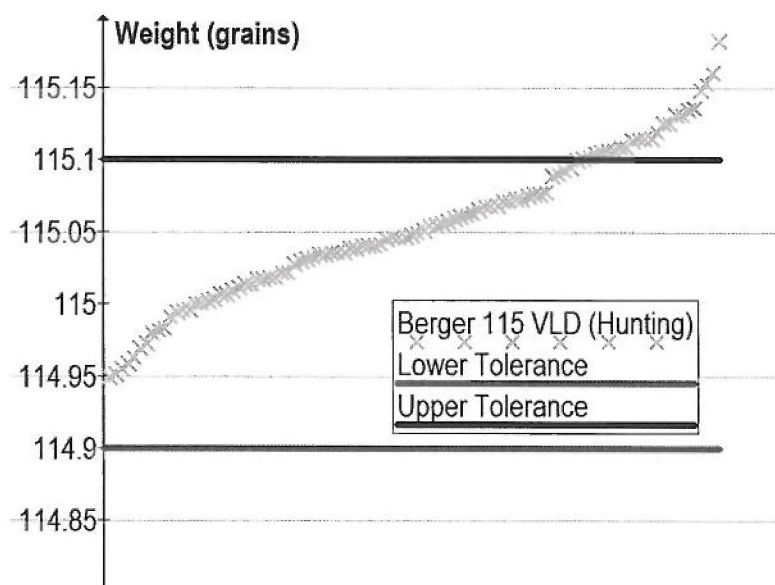
Figure 4: Bullet weights for 115 grain Berger VLD (0.257) .

Berger 155.5 Fullbore 155.5 grain

Berger advertises a weight tolerance of +/- 0.15 grains for their 155.5 grain Fullbore target bullets. The measured bullet weights are shown in Figure 5. Twelve of 100 bullets measured too heavy, with an additional eight measuring right on the upper limit of the specified tolerance. The mean bullet weight was 155.574 grains with a standard deviation of 0.073 grains. Even though some bullets were outside of Berger's advertised specification, all bullets measured were under the 156 grain limit for NRA International Fullbore Prone Competition (NRA 2011).
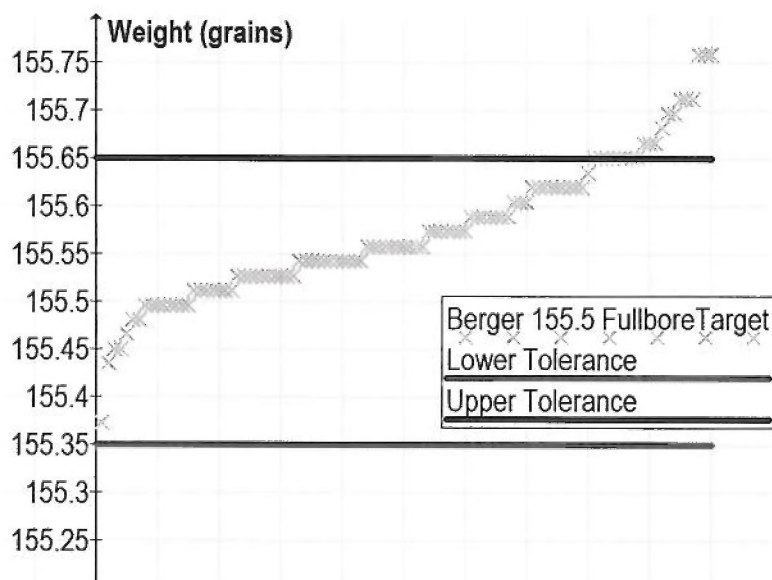

Figure 5: Bullet weights for 155.5 grain Berger Fullbore Target.

Berger 168 grain VLD

Berger claims a weight tolerance of +/- 0.15 grains for their 168 grain bullets. As circumstances would have it, one of the authors (MC) was so eager to shoot this bullet that he didn't wait until his co-authors measured them. Consequently, only 77 bullets remained in the box for measuring, results of which are shown in Figure 6. A significant number of bullets (26 of 77) were above the upper tolerance limit. The mean bullet weight was 168.114 grains with a standard deviation of 0.061 grains.
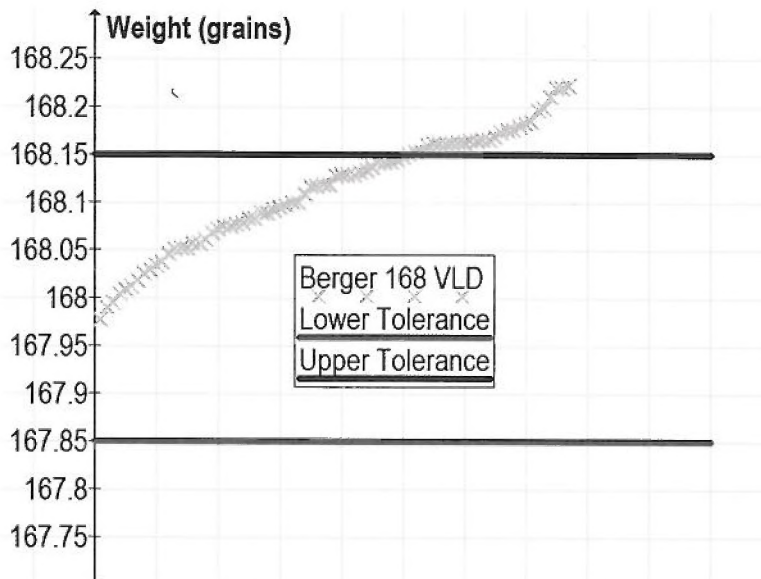

Figure 6: Bullet weights for 168 grain Berger VLD.

Berger 230 grain Match Hybrid Target

Berger opens up their weight specification to +/- 0.2 grains for bullets above 175 grains, and the measurements for the new 230 grain Match Hybrid Target are shown in Figure 7. These bullets are sold in boxes of 50, and 49 out of the 50 bullets measured are within specification. The mean weight was 230.021 grains with a standard deviation of 0.091 grains.
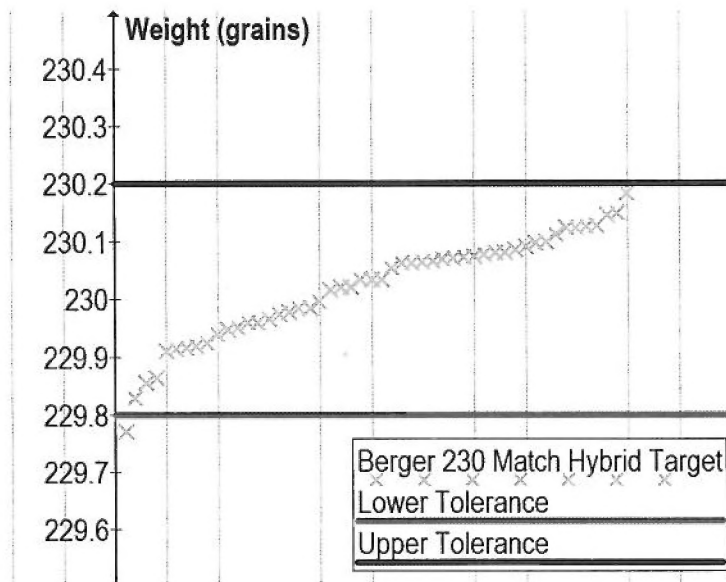
Figure 7: Bullet weights for 230 grain Berger MHT.

Discussion

Since Berger is the only bullet manufacturer we know of to specify weight tolerances, it did not seem appropriate to produce graphs and analysis for bullets from other manufacturers analogous to the above analysis of the Berger bullets. However, it is somewhat informative to present a table of all the bullets we've measured along with the standard deviation and extreme spread of bullet weights. This table is presented as an appendix. Note that to broaden the available data, a number of partial boxes were measured so that the reported results do not include a full box in some cases. However, in no case were the missing bullets selected by weight so that the remaining bullets represent a random sample of the bullets originally in the box.

The results section might leave the reader with the impression that Berger does not really do a good job keeping bullet weight tolerances tight. Careful review of the data in the appendix shows that Berger is one of the better manufacturers, and that in every case, the standard deviation is less than a part in 1000 (one tenth of one percent), and in many cases Berger bullets have a standard deviation from the mean of less than 1 part in 2000.

Another trend apparent in the table is the propensity for solid copper and other lead-free bullet designs to have larger standard deviations, above 0.1% in most cases. And this is not a case of a single manufacturer having difficulty with weight tolerances, because lead-free bullets from Nosler, Barnes, and Cutting Edge all have significantly larger standard deviations than most of the conventional jacketed lead bullets. The two military bullets, M855 and M193, are also among the bullets found to have the largest weight deviations.

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Acknowledgements

References

NRA INTL FULLBORE PRONE. 2011.
http://www.nrahq.org/compete/rules/rul_fb_prone_11.pdf

Berger Bullets. 2011.
http://www.bergerbullets.com/Information/Why%20Are%20Berger's%20Better.html .

Appendix:

Manufacturer	Caliber	Bullet	Weight Mean	Stdev	Extreme Spread	Percent Stdev	Percent Extreme
	inches		(grains)	(grains)	(grains)	(percent)	(percent)
Berger	0.308	168 VLD	168.123	0.064	0.278	0.038	0.165
Berger	0.308	230 BHT OTM	230.021	0.091	0.412	0.039	0.179
Nosler	0.308	165 NAB	164.947	0.075	0.293	0.046	0.178
Berger	0.308	155.5 FBBT	155.574	0.073	0.386	0.047	0.248
Nosler	0.308	150 NBT	150.021	0.075	0.278	0.050	0.185
Sierra	0.308	220 SMK	220.032	0.136	0.525	0.062	0.238
Hornady	0.308	208 AMAX	207.947	0.137	0.648	0.066	0.312
Hornady	0.308	110 VMAX	110.149	0.079	0.432	0.072	0.392
Nosler	0.308	220 NPT	220.033	0.163	0.664	0.074	0.302
Nosler	0.308	165 NBT	164.992	0.132	0.432	0.080	0.262
Hornady	0.308	110 HSP	109.949	0.088	0.509	0.080	0.463
Nosler	0.308	150 NET	150.134	0.127	0.664	0.085	0.442
Cutting Edge	0.308	130 BrHP	129.968	0.119	0.594	0.092	0.457
Speer	0.308	130 SpSP	130.538	0.120	1.235	0.092	0.946
Nosler	0.308	125 NBT	124.941	0.118	0.494	0.094	0.395
Hornady	0.308	155 AMAX2	154.913	0.148	0.670	0.096	0.432
Hornady	0.308	155 AMAX	154.884	0.170	0.833	0.110	0.538
Barnes	0.308	168 TTSX	168.090	0.192	0.818	0.114	0.487
Hornady	0.264	140 AMAX	140.047	0.101	0.619	0.072	0.442
Barnes	0.257	100 TTSX	100.057	0.160	0.694	0.160	0.694
Barnes	0.257	100 TTSX2	100.089	0.147	0.494	0.147	0.493
Nosler	0.257	110 NAB	109.932	0.150	0.664	0.137	0.604
Nosler/Win	0.257	85 CTBST	85.023	0.081	0.432	0.095	0.508
Barnes	0.257	100 XBT	100.212	0.107	0.401	0.107	0.400
Nosler	0.257	100 NBT	100.071	0.122	0.370	0.122	0.370
Speer	0.257	100 SpBT	99.896	0.104	0.027	0.104	0.027
Berger[1]	0.257	115 VLD	115.071	0.053	0.262	0.046	0.228
Barnes	0.224	53 TSX	53.054	0.078	0.332	0.147	0.625
Barnes	0.224	53 TSX2	53.069	0.064	0.245	0.120	0.462
Barnes	0.224	50 TTSX	50.187	0.068	0.282	0.136	0.563
Barnes	0.224	55 TTSX	55.105	0.066	0.327	0.120	0.594
Berger	0.224	62 FBV	61.981	0.050	0.293	0.081	0.473
Berger	0.224	62 FBV 2	61.979	0.053	0.278	0.085	0.448
Berger	0.224	62 FBV 3	62.031	0.032	0.160	0.051	0.259
Berger	0.224	52 FB	52.097	0.035	0.198	0.068	0.379
Nosler	0.224	69 NCC	69.107	0.054	0.401	0.078	0.581
Nosler	0.224	55 NBT	55.121	0.159	0.710	0.289	1.288
Nosler	0.224	55 NBT2	55.102	0.046	0.247	0.084	0.448
Nosler	0.224	40 NBTLF	40.132	0.122	0.540	0.304	1.346
Nosler	0.224	55 CTBST	55.019	0.055	0.318	0.100	0.578
Hornady	0.224	55 HSP	55.180	0.053	0.370	0.096	0.671
Hornady	0.224	40 VMAX	40.034	0.024	0.123	0.060	0.308
Hornady	0.224	53 VMAX	52.810	0.098	0.540	0.185	1.023
Hornady	0.224	53 VMAX 2	53.008	0.111	0.489	0.209	0.923
Hornady	0.224	60 VMAX	59.924	0.038	0.170	0.063	0.283
Sierra	0.224	55 SBK	54.986	0.049	0.293	0.089	0.533
Barnes	0.224	50 BVG	50.638	0.238	1.378	0.470	2.722
Cutting Edge	0.224	55 BRHP	55.044	0.084	0.423	0.153	0.768
Lake City	0.224	62 M855	62.706	0.166	0.640	0.265	1.021
Lake City	0.224	55 M193	55.049	0.181	0.680	0.328	1.235

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[1] This is a different box of bullets than discussed in the text.